



Pacific Island Network Vital Signs Monitoring Plan

Appendix E: Topical Working Group Report – Vertebrate Fauna

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Pacific Island Network (PACN)

Territory of Guam

War in the Pacific National Historical Park (WAPA)

Commonwealth of the Northern Mariana Islands

American Memorial Park, Saipan (AMME)

Territory of American Samoa

National Park of American Samoa (NPSA)

State of Hawaii

USS Arizona Memorial, Oahu (USAR)

Kalaupapa National Historical Park, Molokai (KALA)

Haleakala National Park, Maui (HALE)

Ala Kahakai National Historic Trail, Hawaii (ALKA)

Puukohola Heiau National Historic Site, Hawaii (PUHE)

Kaloko-Honokohau National Historical Park, Hawaii (KAHO)

Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)

Hawaii Volcanoes National Park, Hawaii (HAVO)

<http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

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EXECUTIVE SUMMARY

The terrestrial vertebrate fauna workgroup report addresses native and alien vertebrate populations and communities found within and near parks. Native vertebrates that are likely to be of high concern for monitoring include rare species and groups, federally listed threatened or endangered species, animals with important functional roles in ecosystem processes, animals with special cultural significance, and animals that serve as indicators of natural or anthropogenic environmental change. Alien vertebrates of particular concern for monitoring include species in which parks are controlling (or want to control) due to their ability to reduce native biodiversity, species that pose specific threats to high priority native plants or animals, and species that pose identified or potential human health risks. Marine birds, water birds, and shorebirds are also considered here.

This report's objectives are to identify and summarize existing knowledge and understanding of terrestrial vertebrate fauna, as well as to identify important information gaps. In conjunction with other workgroup reports, this information will be used to prioritize, design, and construct a comprehensive ecological monitoring program for the eleven parks in the Pacific Island Network (PACN).

The islands covered in this report are located in Micronesia in the western Pacific (Guam and Saipan), in Hawaii in the central Pacific (Hawaii, Maui, Molokai, and Oahu), and in American Samoa in the south central Pacific (Tutuila, Tau, Ofu, and Olosega). The native terrestrial vertebrate fauna in the Pacific Island parks is quite depauperate when compared to the continental U.S., Asia, or continental islands. Smaller land areas and concomitantly smaller populations, coupled with high levels of endemism, elevate threats in the Pacific islands compared to mainland situations.

Legal mandates concerning terrestrial fauna include federal legislation for endangered species and migratory birds, National Park Service (NPS) regulations, enabling Legislation, NPS Management Policies (2001), Executive Orders, Director's Orders, and Commonwealth of the Northern Mariana Islands (CNMI), American Samoa, Guam and Hawaii state and local laws pertaining to wildlife.

A **conceptual model** is required by the NPS's Inventory and Monitoring (I&M) program to facilitate communication between managers, scientists, stakeholders, and the public during the monitoring planning process. The terrestrial vertebrate fauna workgroup developed a stressor-focused model for native terrestrial fauna in PACN parks with the following components: **drivers**, which cause major ecosystem change; **stressors**, which are the physical, chemical, or biological perturbations to a system resulting from model drivers; and **ecosystem responses** to stressors.

Past, existing, or ongoing terrestrial vertebrate monitoring primarily concentrates on rare or listed species and on alien mammals. The needs identified for terrestrial vertebrate monitoring in network parks focus on rare or listed species and those with cultural significance. Stressors, identified by parks, include invasive aliens and biodiversity loss, climate change (including sea level rise), lava flows, and fire or altered fire regimes.

Information needs include editing of the NPSpecies (inventory) database for all parks. Additionally, ALKA, AMME, and WAPA need baseline inventories of their vertebrate terrestrial fauna.

INTRODUCTION

SCOPE OF TOPIC AREA

The vertebrate fauna group addresses native and alien vertebrate populations and communities found within parks. Native vertebrates that are likely to be of high concern for monitoring include a) rare species and groups, b) federally listed threatened or endangered species, c) animals with important functional roles in ecosystem processes such as pollination and seed dispersal, d) animals with special cultural significance, and e) animals that serve as indicators of threats to, or declines in, communities or ecosystems. Alien vertebrates of particular concern for monitoring include species in which parks are controlling (or want to control) due to their ability to reduce native biodiversity, species that pose specific threats to high priority native plants or animals, and species that pose identified or potential human health risks (e.g., rats as vectors of leptospirosis in freshwater sources, soil, campgrounds/campsites, picnic areas, etc.). Marine vertebrate fauna and freshwater aquatic animals will not be considered, as both of these are covered by their respective workgroups. Marine birds, water birds, and shorebirds will be addressed in this report.

BACKGROUND

The islands covered in this report are located in Micronesia in the western Pacific (Guam and Saipan), in Hawaii in the central Pacific (Hawaii, Maui, Molokai, and Oahu), and in American Samoa in the south central Pacific (Tutuila, Tau, Ofu, and Olosega).

The native terrestrial vertebrate fauna in the Pacific island parks is quite depauperate when compared to the continental U.S., Asia, and continental islands. Smaller land areas and concomitantly smaller populations, plus high levels of endemism, make many threats potentially more serious in the Pacific islands than in mainland situations. For example, avian diseases such as malaria, that are naturally part of U.S. mainland ecosystems, are alien in Hawaii. Here, avian disease has been devastating to native land birds. Thus, incipient or potential threats also must be evaluated within the context of the fragility of remote island fauna. For example, West Nile Virus, carried by infected mosquitoes entering Pacific islands through air and sea cargo, could have dire consequences for native species.

Additionally, there may be distinct cultural affiliations between Pacific Islanders and native or early introduced wildlife.

MONITORING GOALS AND OBJECTIVES

The objective of this report is to identify and summarize existing knowledge and understanding of terrestrial vertebrate fauna, as well as to identify important information gaps. In conjunction with other workgroup reports, this information ultimately will be used to prioritize, design, and construct a comprehensive ecological monitoring program for the network's 11 parks.

Terrestrial vertebrates may be included in network monitoring based on roles as important components of ecosystems, indicators of broader natural or anthropogenic environmental change, or as keystones in native ecosystems.

LEGISLATION AND POLICY

As a federal agency, the NPS operates under a hierarchy of legislative mandates including federal laws, executive orders, Department of the Interior and NPS policies and directives, as well as county, state, commonwealth, and territorial regulations. Management of submerged resources is complicated by jurisdictional or administrative issues that are often managerially more challenging than similar issues on land. These complexities require the NPS to cooperate with numerous and often overlapping federal and local agencies to achieve its objectives.

I & M - NATURAL RESOURCE CHALLENGE

The Natural Resource Challenge (NRC), initiated in 1999, is an action plan for preserving natural resources through the NPS. The NRC assisted NPS in establishing 32 I&M networks, which includes 270 national parks, monuments, sites, etc. These lands were grouped into networks based on geographic and natural resource characteristics. The I&M Program is designed to first complete basic inventories of natural resources in parks, on which to base long-term monitoring efforts. Monitoring programs are based on critical parameters (Vital Signs) within each network to incorporate into natural resource management and decision-making. “Vital Signs are measurable, early warning signals that indicate changes that could impair the long-term health of natural systems” (NPS 2003).

INTERNATIONAL

Endangered Species Act

The Endangered Species Act of 1973 is administered by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). The Endangered Species Act requires conservation of ecosystems upon which endangered and threatened species depend, that all federal departments and agencies conserve endangered and threatened species, and that each federal agency insures that their actions are not likely to jeopardize endangered or threatened species. These actions are primarily carried out via endangered species permits for activities involving listed species, consultations for actions not covered under an endangered species permit that may affect listed species, and recovery plans which should be carried out whenever possible.

Migratory Bird Treaty Act

“Unless permitted by regulations, the Migratory Bird Treaty Act of 1918 provides that it is unlawful to pursue, hunt, take, capture or kill, attempt to take, possess, offer to or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product, manufactured or not”. “Subject to limitations in the Act, the Secretary of the Interior may adopt regulations determining the extent to which, if at all, hunting, taking, capturing, killing, possessing, selling, purchasing, shipping, transporting or exporting of any migratory bird, part, nest or egg will be allowed, having regard for temperature zones, distribution, abundance, economic value, breeding habits and migratory flight patterns”.

FEDERAL

Executive Orders

Executive Orders are official documents, through which the President of the United States manages the operations of the Federal Government.

Executive Order 13112 - Invasive Species/ Exotic Species requires parks to prevent the introduction of invasive species, to detect and control populations in a cost-effective and environmentally sound manner, to monitor alien species populations, and to provide restoration of native species and habitat conditions in ecosystems that have been invaded. This order also requires research on prevention of invasive species' introductions, research on sound control, and public education on invasive species.

Executive Order 11990- Protection of Wetlands requires all federal agencies to “minimize the destruction, loss, or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands”. Unless no practical alternative exists, federal agencies must avoid any activities that have the potential to adversely affect wetland ecosystem integrity. NPS guidance pertaining to this Executive Order is stated in Floodplain and Wetland Protection Guidelines (NPS 1980).

NPS

The National Park Service Organic Act

The NPS Organic Act of 1916 is the core of park service authority and the definitive statement of the NPS mission to promote and regulate the use of the federal areas known as national parks, monuments, and reservations. The act establishes the purpose of national parks “.... to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.”

Park Enabling Legislation

The act establishing NPSA recognized the importance of the park's tropical vegetation as one of the last remaining undisturbed paleotropical forests and as habitat of Pacific flying foxes (*Pteropus samoensis*, *P. tonganus*). Enabling legislation at HAVO and HALE requires preservation from injury of all timber, birds, mineral deposits, and natural curiosities or wonders within, and that these parks should be retained in their natural condition as nearly as possible. Enabling legislation for all other parks within the PACN does not have specific language regarding terrestrial vertebrate fauna.

NPS Management Policies

NPS management policies are designed to provide clear and continuously updated information on policies and required and/or recommended actions, as well as any other information that will help manage parks and programs effectively. Management policies pertaining to vertebrate fauna include the following:

Restoration of Natural Systems 4.1.5. Re-establishes natural functions and processes, biological and physical components, and biological community structure. Examples include removal of

exotic species, removal of contaminants and non-historic structures, and restoration of native plants and animals.

Plant and Animal Population Management Principles 4.4.1.1. Specifies that parks should work with partners to manage species that cross park boundaries as well as those found outside parks.

Management of Native Plants and Animals 4.4.2. Specifies when intervention is permissible to maintain native species. For example, this may apply if a population occurs in an unnaturally high or low concentration as a result of human influences and it is not possible to mitigate the effects of the human influences. This policy protects rare, threatened, or endangered species and allows for intervention where it meets specific park management objectives.

Restoration of Native Plant and Animal Species 4.4.2.2. Specifies when restoration may occur and limits highly manipulative activities for restoration.

Management of Threatened or Endangered Plants and Animals 4.4.2.3. Requires that NPS will survey for, protect, and strive to recover all species native to the NPS units that are listed under the Endangered Species Act. Requires that NPS meets obligations under the NPS Organic Act.

Maintenance of Altered Plant Communities 4.4.2.5. Limits and prohibits the use of exotic species. Maintains threatened and endangered species.

Removal of Exotic Species Already Present 4.4.4.2. Prioritizes management and eradication of exotic species already present within a park.

Biotic Cultural Resources 5.3.5.2.5. Management of biological resources with cultural significance.

NPS-supported Studies 8.11.2. Inventory, monitoring, and research studies to support management needs and objectives.

Natural Resource Management Guidelines: Establishes guidelines for native animal management, hunting and trapping, as well as subsistence and other traditional uses

Director's Orders

Director's orders provide guidance for implementing certain aspects of NPS management policies, and are used as a vehicle for updating management policies between publishing dates.

Director's Order #77-1- Wetland Protection: the purpose of this Director's order is to establish NPS policies, requirements, and standards for implementing *Executive Order 11990- Protection of Wetlands*, to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practical alternative.

REGIONAL

State of Hawaii

Chapter 195D-1 thru 5 of the State of Hawaii Revised Statutes

Statutes administered by the State of Hawaii, Department of Land and Natural Resources (DLNR) state that it is unlawful to take, possess, transport, export, process, sell, offer for sale, or ship a species of aquatic life, wildlife, or land plants in need of conservation, except when

permitted by DLNR. DLNR may determine an indigenous species to be endangered or threatened because of any of these factors: the present or threatened destruction, modification, or curtailment of its habitat or range; over utilization for commercial, sporting, scientific, educational, or other purposes; disease or predation; inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence within Hawaii. DLNR is also authorized to acquire by purchase, donation, or otherwise lands or interests therein needed to carry out conservation programs.

Hawaii Tropical Forest Recovery Act (1992)

This act authorizes the Secretary of Agriculture and the U.S. Forest Service to establish biological control agents for non-native species. It creates a task force to develop an action plan to "promote public awareness of the harm caused by introduced species" and to develop recommendations on "the benefits of fencing or other management activities for the protection of Hawaii's native plants and animals from non-native species, including the identification and priorities for the areas where these activities are appropriate".

Commonwealth of the Northern Mariana Islands

Division of Fish and Wildlife

The CNMI Division of Fish and Wildlife (DFW) is mandated by local law (Public law 2-51) to establish clear and uniform regulations governing hunting, fishing, conservation of fish and wildlife, and endangered species. DFW regulations are developed in order to conserve and preserve wildlife resources and their habitats. The regulations establish hunting and fishing seasons, legal and illegal equipment, declare endangered species, and determine sensitive habitat. See website www.dfw.gov.mp/interest.htm for details.

American Samoa

Department of Marine and Wildlife Resources (DMWR)

The functions of the American Samoa Department of Marine and Wildlife Resources (DMWR) are to protect and manage American Samoa's marine and wildlife resources to the extent intended to best benefit the people of American Samoa while ensuring the integrity of such resources for posterity. The majority of DMWR's projects are federally funded through the Federal Aid in Wildlife and Sport Fish Restoration grants (Federal Aid in Wildlife Restoration Act of 1937) and monies from the National Marine Fisheries Service Western Pacific Fish Information Network.

The American Samoa Coastal Management Program

The American Samoa Coastal Management Program is administered by the Department of Commerce under Public Law 21-35, the American Samoa Coastal Management Act of 1990, and ASCA (American Samoa Code Annotated) 24.0501. The American Samoa Coastal Management Act mandates the establishment of a system of environmental review, along with economic and technical considerations at the territorial level, intended to ensure that environmental concerns are given appropriate consideration in the land use decision-making process. Coastal resources include, but are not limited to, land, air, water, minerals, flora, fauna, objects of historic or aesthetic significance of the territorial coastal zone, submerged lands, reef systems, groundwater

recharge areas, archaeological/cultural/historic resource sites and properties, Special Management Areas, pristine ecosystems, mangroves, wetlands, beaches, areas of scientific interest, recreational areas, undisturbed native vegetation, and critical habitat. Local government agencies fall under this mandate.

Guam

The Department of Agriculture's Division of Aquatic and Wildlife Resources (DAWR) is responsible for regulating fish and game in and around Guam under Title 5, Guam Code Annotated (GCA), Section 63102. The government of Guam has two legal forums to establish law, either through the legislature or departmental authority. When the various government departments were created, they were delegated the authority to make regulatory changes. In order to alter regulations, the agency must hold at least one public hearing, and then submit copies of the proposed changes, a copy of the add announcing the public hearing, a copy of the attendance list to the public hearing, and a copy of the hearing testimonies to the Attorney General's Office, followed by the governor. Upon registry at the legislature, the documents are open for 90 days during which the legislature can approve, alter, amend, or disapprove the proposal. If no action is taken within 90 days, these changes become law.

ECOLOGICAL CONTEXT

GEOGRAPHY

All the PACN network parks are located on tropical islands in the Pacific Ocean. Eight of the parks are in the Hawaiian Islands in the Central Pacific between 19 and 22 degrees North latitude. HAVO, KAHO, PUHE, PUHO, and the recently designated ALKA are on the island of Hawaii, the youngest of the main Hawaiian Islands at the southern and eastern end of the archipelago. HAVO is located on the southeast slope of Hawaii Island, where it extends from sea level to the summits of Kilauea and Mauna Loa Volcanoes. The newly designated Kahuku unit of HAVO is positioned on southern Mauna Loa and extends down both the eastern and western flanks of the volcano. PUHE, KAHO, and PUHO are coastal parks of the western side of the island. KAHO is centrally located with PUHE to the north and PUHO to the south. HALE is on Maui, the second youngest Hawaiian Island. HALE extends from sea level to the summit of East Maui. KALA is on a peninsula projecting from the north shore of Molokai, centrally located in the main Hawaiian Islands. USAR is within Pearl Harbor on southern or leeward Oahu. Two PACN parks are situated in the western Pacific Ocean between 13 and 15 degrees north latitude in Micronesia. WAPA is on the western side of the island of Guam and AMME is on the west coast of Saipan, one of the Northern Mariana Islands. NPSA is on the Polynesian islands of American Samoa, approximately 14 degrees south latitude. One unit of NPSA is on the island of Tutuila, and three others are on Tau, Ofu, and Olosega of the Manua Island group 96 km (60 miles) east of Tutuila.

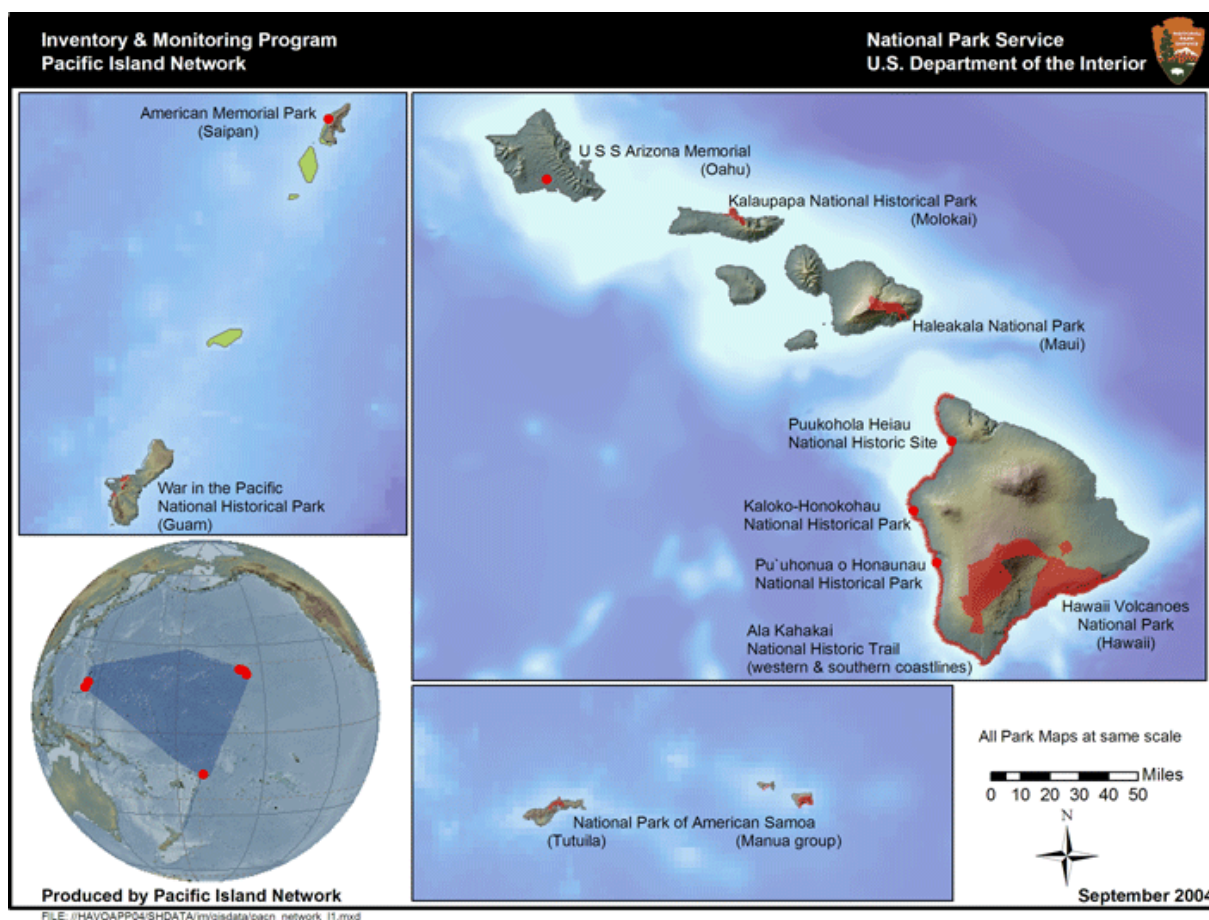


Figure 1. Pacific Island Inventory and Monitoring Network

GEOLOGY

The parks of the Western Pacific (WAPA, AMME) are on the islands of Guam and Saipan which have long-extinct volcanoes. These islands have complicated geologic origins involving both volcanism and subduction of the Marianas Trench. Hence, the northern half of Guam and portions of Saipan have limestone substrates elevated above a weathered volcanic base. WAPA units are on the volcanic substrates of the southern half of Guam, and at least one unit includes elevated limestone caps.

The islands of American Samoa and Hawaii are oceanic volcanic islands arising from hotspots. The oldest of the Samoan Islands are dated at more than two million years, but there was volcanic activity between Tau and Olosega approximately 150 years ago (Whistler 1994). In Hawaii, HALE protects the summit of the inactive Haleakala Volcano and its impressive crater, which is the result of stream erosion, the merging of Kaupo and Keanae Valleys, and subsequent volcanic activity. KALA encompasses the Kalaupapa peninsula, formed on the north shore of Molokai during the Pleistocene (MacDonald and Abbott 1970). The volcanoes on both Molokai and Oahu are extinct.

The five parks on Hawaii Island are on active or dormant volcanoes. A significant portion of HAVO is covered with recent lava flows that are sparsely vegetated. HAVO also contains the rift zones and summit calderas of both Mauna Loa and Kilauea Volcanoes, two of the most

active volcanoes on earth. PUHO is on prehistoric pahoehoe flows of Mauna Loa, and PUHE substrates are old weathered soils of Kohala Volcano. All substrates of KAHO are flows from Hualalai Volcano less than 10,000 years old, including one sparsely-vegetated lava flow dated at 1,000-3,000 years (Moore *et al.* 1987).

ELEVATION GRADIENTS

Among the Hawaiian parks, HAVO and HALE have the greatest elevational range, extending from sea level to the summits of tall volcanoes >3,000 m (>10,000 ft) in elevation. KALA has an elevational range from sea level to almost 1,220 m (4,000 ft) elevation. The three parks of leeward Hawaii Island are coastal parks and extend upslope to an elevations less than 100 m. ALKA is also in the coastal lowlands of western and southern Hawaii Island.

Among the three Western Pacific parks, AMME is restricted to coastal lowlands on the western shore of Saipan. WAPA includes both coastal units and inland sites on the slopes of Mt. Alifan and Mt. Tenjo, with one unit extending above 305 m (1,000 ft) in elevation. NPSA is composed of four units; Ofu and Olosega are largely coastal but the Tutuila and Tau units range from sea level to 491 m (1,610 ft) and 966 m (3,170 ft) elevation, respectively. The planned expansion of NPSA on Ofu and Olosega will include the summits of both islands, which are 499 m (1,621 ft) and 639 m (2,096 ft), respectively.

RAINFALL AND CLIMATE

The largest two Hawaiian parks, HAVO and HALE, include within their boundaries several climatic zones with a range of rainfall regimes. HAVO contains two of the four rainfall minima of Hawaii Island, the Kau Desert with mean annual rainfall <750 mm and the interior lands of Mauna Loa. The highest mean annual rainfall within the park is found in Olaa Tract, a rain forest with >4,000 mm per year (Giambelluca *et al.* 1986). In general, the eastern windward portion of HAVO has high rainfall, which diminishes upslope, particularly above the trade wind inversion layer near 1,830 m (6,000 ft) elevation. The upper elevations of the park are moist to very dry, and the summit of Mauna Loa receives on average <500 mm precipitation. The leeward, western portions of HAVO are in rain shadows of Mauna Loa and Kilauea summit, and are typically dry.

HALE also has a range of climates, as it extends from sea level on the windward, eastern slope of Haleakala to the summit of East Maui. This park also includes lands in the leeward rain shadow of Haleakala, down to 1,220 m (4,000 ft) elevation. Annual precipitation in the park varies from 1,250 mm in the Crater, the southern slope, and Kaupo Gap to >6,000 mm on the upper northeastern slopes of Haleakala. KALA, on the north shore of Molokai receives 1,000 mm of precipitation annually at sea level and >3,000 mm at the upper elevations of Waikolu Valley (Giambelluca *et al.* 1986). The USAR on Oahu is located within Pearl Harbor on the dry leeward side of the island in an area that has on average 600 mm rainfall per year.

The four Hawaii Island parks are in relatively low rainfall areas with constant warm temperatures and pronounced daily wind patterns of land and sea breezes (Blumenstock and Price 1967). KAHO has a mean annual rainfall of approximately 600 mm and a seasonal climate with higher rainfall during summer months (Canfield 1990a). The climate of PUHO is similar to that of KAHO, with mean annual precipitation of 659 mm. PUHE is located within one of the four rainfall minima of the island of Hawaii and receives <250 mm of rain annually (Giambelluca *et*

al. 1986). Because ALKA covers a large linear coastal transect along West Hawaii, the rainfall pattern is variable.

The climate of Guam and the Northern Marianas (CNMI), including Saipan, is warm, wet, and tropical. Temperature varies between 90 and 70° F. Relative humidity is high, often exceeding 80% and seldom falling below 50%. The rainfall pattern is strongly seasonal with a wet season from July to November and a pronounced dry season from December to June. Average annual rainfall of the Marianas is 2,160 mm (85 in) (Baker 1951), and on Guam the annual mean is 2,175 mm (Mueller-Dombois and Fosberg 1998). Typhoons are yearly events, which occur during the monsoonal wet season. Trade winds blow from the northeast, but easterly and southeasterly winds prevail during several months in the spring (Baker 1951). Because Guam and the Marianas are relatively low islands, there is no pronounced rain shadow effect, and leeward shores are not drier than those of the windward sides (Mueller-Dombois and Fosberg 1998).

NPSA has a warm tropical climate with little seasonal variation in temperature. Rainfall is high in the four units of the park. On Tutuila, annual rainfall averages 3,200 mm (124 inches at the airport, and may be even higher on the upper mountain slopes within the park. Rainfall is seasonal with greater monthly means from October to May and a dry season from June to September. Hurricanes are occasional but not annual events (Whistler 1994). Tau Island unit is only about 96 km (60 miles) east of Tutuila and shares its warm and wet tropical climate. Tau average rainfall is more than 2,500 mm per year and is highest in December. The dry season is June to September, and droughts sometimes occur on the island (Whistler 1992).

CONCEPTUAL ECOLOGICAL MODELS

The components of the conceptual ecological model for terrestrial vertebrates are outlined in Figure 2.

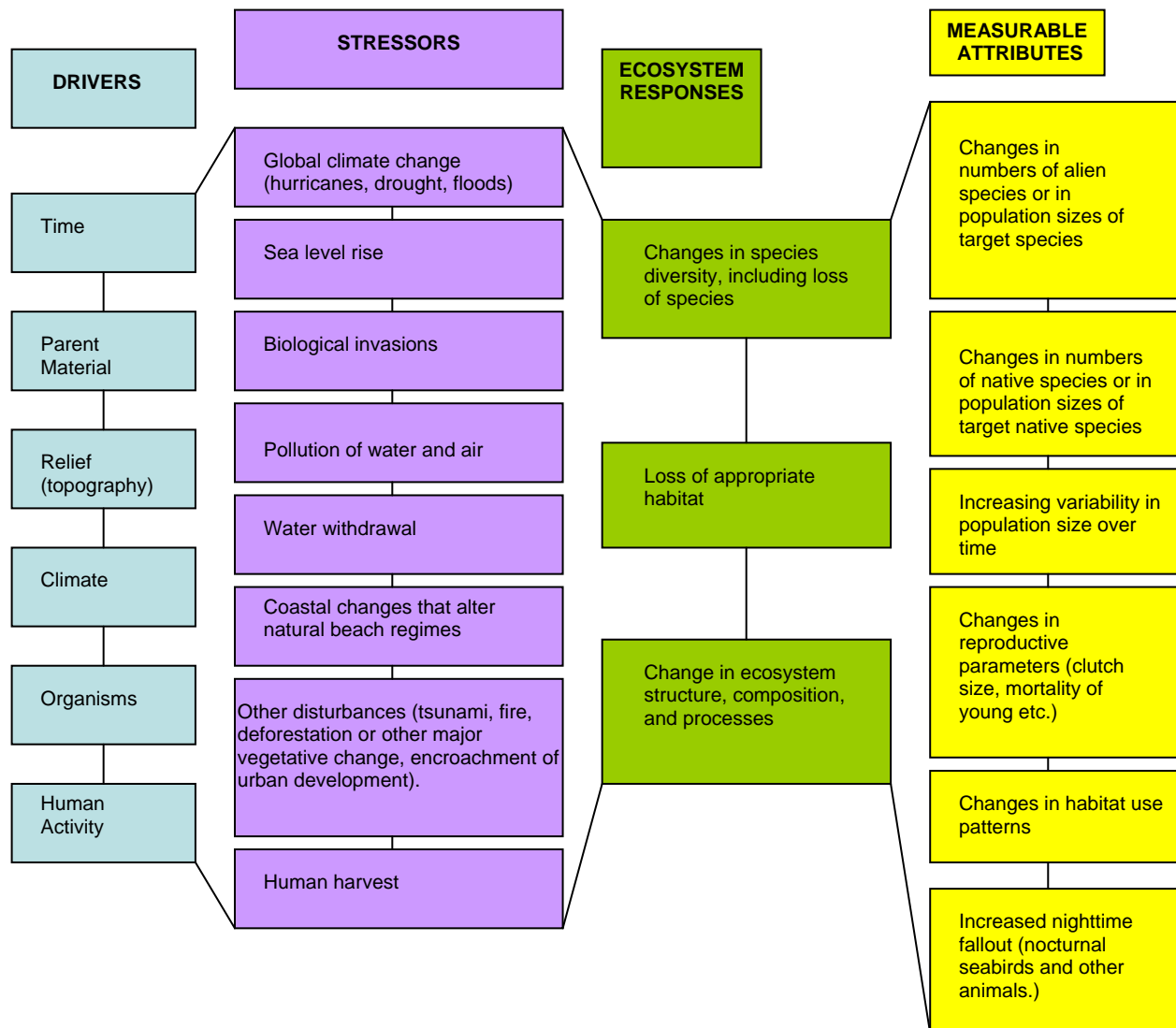


Figure 2. Conceptual ecological model for terrestrial vertebrate fauna in the Pacific Island Network.

DRIVERS

Drivers are major forces of ecosystem change. Jenny (1980) identified six major categories of ecological drivers including time, parent material, relief/topography, climate, organisms, and human activity. Changes in magnitude or direction of these drivers result in changes in species composition, diversity, or patterns in population abundance or dispersion. Human activity can significantly alter the nature or magnitude of a natural driver, creating an unnatural type or level of stress on a community with subsequent changes in its structure or function.

STRESSORS

Stressors are physical, chemical, or biological perturbations to a system resulting from the (model?) drivers. Global climate change, sea level rise, biological invasions (including predatory invasives, competition facilitating the spread of pathogens, and impacts of invasive

species on habitat), pollution, water withdrawal, coastal changes, other disturbances or catastrophes (tsunami, fire, wholesale conversion or loss of vegetation such as from deforestation or conversion to agricultural use), habitat restoration, and human harvest were identified as stressors. Stressors identified in the conceptual model have differing local and park effects on terrestrial fauna throughout the network. Our assessment of these effects attempted to anticipate the most serious impacts, particularly to native fauna.

The *change in climate patterns* over various time scales may have a variety of effects on existing ecosystems and their components. Among these changes are increased frequency and severity of weather catastrophes such as droughts, floods, hurricanes, and El Nino- Southern Oscillation (ENSO) events. One or a series of these events can cause precipitous declines, particularly in already-small populations of native terrestrial species. Global climate change and associated severe weather events could change sea surface temperatures, impacting food supply for marine birds known to be present at HALE, HAVO, NPSA, and possibly present at KAHO, PUHO, KALA, and WAPA. Severe weather events such as storms and floods during the breeding season can impact ground and open-cup nesting birds in HALE, HAVO, KAHO, KALA, NPSA, and possibly WAPA.

Sea level rise may result in loss of wetland and shoreline habitat for water birds at KAHO, habitats adjacent to ALKA, and wetland birds at AMME. Migratory shorebirds, which currently use shorelines in all network parks, may lose feeding and roosting habitat. Shoreline-nesting seabirds at KAHO and possibly KALA could lose nesting habitat. Sea turtles may lose nesting and/or basking habitat at HAVO, NPSA, KALA, KAHO, ALKA, and PUHO. Monk seal pupping beaches may be lost at KALA.

Biological invasions can impact native animals by predation, competition, facilitating the introduction of alien diseases and parasites, and displacing food supply, roost sites, or other important habitat components. Invasive species may be even more damaging to native species and ecosystems on a global scale than the loss and degradation of habitats.

Pollution from nearby harbors or upslope areas may degrade water bird and migratory bird habitat. The AMME wetland, habitat for the endangered nightingale reed warbler, is threatened by water quality degradation. KAHO, PUHO, and PUHE wetland habitats, used by endemic water birds and migratory species, are threatened by pollution from upslope or adjacent harbors. Pollution appears to be a minimal problem at NPSA at this time (R. Monello, pers.comm.).

Water withdrawal causes reduction and degradation of wetland and estuarine habitat, and could change soil moisture, and thus, vegetative cover. The PUHE wetland may be threatened by upslope dewatering which may impact endemic water birds and some shorebirds.

Coastal changes include construction or mining that alter natural beach regimes, as well as encroaching urbanization and heavy use by humans. Increased human-use disturbs shorebirds, basking and nesting turtles, and basking monk seals. Shorelines outside parks are often heavily used and impacted by pets and lights. Thus, the more protected confines of the parks may become increasingly important refugia for these animals.

Other disturbances or catastrophes include tsunami, fire, wholesale conversion or loss of vegetation from deforestation or conversion to agricultural use, and urban encroachment.

These large-scale, often sudden, changes have caused loss of habitat for Bulwer's petrels at HAVO (subsidence associated with a tsunami) and loss of native bird and reptile habitat from

fire (HAVO, HALE, WAPA). Adjacent deforestation outside HAVO has further reduced forest bird habitat. Loss or fragmentation of less disturbed buffer zones outside all parks has accelerated the invasion of alien plants and predators.

Human harvest includes both legal and illegal methods. In the past, the Pacific pigeon (*Ducula pacifica*) and the many-colored fruit dove (*Ptilinopus perousii*) were harvested at NPSA for subsistence. Since the 1990s, there has been a ban on hunting these birds and fruit bats (*Pteropus samoensis*, *P. tonganus*). Poaching alone may not have an impact on the bat population.

ECOSYSTEM RESPONSES

Ecosystem responses to stressors were identified as follows:

Changes in species diversity include native, alien, and culturally significant species, total loss (extinction or extirpation) of species, and changes in genetic diversity.

Habitat Loss. Rises in sea level may result in the loss of wetland habitat for water birds and migratory birds, and loss of nesting habitat for shoreline nesting seabirds. Fire may also eliminate habitat for native forest birds and reptiles.

Changes in ecosystem structure, composition, and processes. Changes encompass various forms of habitat degradation which may not be tolerable. Invasion of alien, fire-adapted grasses has changed the fire regime, further altering plant composition and possibly nutrient cycling, in low and mid-elevation grasslands at HAVO, HALE, and WAPA. Fauna impacted by these changes include nene (*Branta sandvicensis*) and potentially any native invertebrates still present. Decline of dominant tree species in forest habitat through fire, disease, or selective harvest may affect birds and bats. The loss of native food plants and changes in nutrient cycles impact food availability and quality for nene.

MEASURABLE ATTRIBUTES

Attributes are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. Measurable attributes that were identified in the vertebrate fauna conceptual model are described below.

Changes in abundance of target alien and native species, including culturally significant species. Culturally important species include Hawaiian aumakua or family deities such as pueo (*Asio flammeus sandwichensis*) (HAVO, HALE, KAHO), io (*Buteo solitarius*) (HAVO, PUHO), and gecko or moo (probably in all parks). Seabirds were formerly a food source mentioned in many historic accounts; Hawaiian honeycreepers were harvested for feathers (stories of bird catchers), and nene were used as watch dogs. However, these latter examples may have few modern cultural ties. Other targeted species could include highly invasive aliens controlled by parks, threatened or endangered native species, more common native species that serve as indicators of system change, or keystone species that support native systems.

Population Counts. For threatened, endangered, rare, or indicator/keystone species, population counts or estimates may be possible and desirable. Changes in variability of populations over time may be indicative of negative ecosystem responses. However, in all cases, changes must be distinguishable from any “normal” population fluctuations.

Changes in habitat use patterns. Native species may shift habitats in response to aliens, climate change, or habitat degradation. In some cases, species remain in marginal habitat only. Presence/absence monitoring may be appropriate here.

Changes in reproductive parameters such as clutch size, hatching success, and juvenile mortality can be monitored.

Changes in demography could serve as an early warning of reproductive failure, particularly in long-lived species with lower reproductive rates. However, it must be possible to distinguish ages or age classes.

Changes in nighttime fallout of seabirds and possibly other nocturnal animals are indicative both of population status in colony areas (e.g., Kauai fallout data) and of problems with light pollution.

PARK AND NETWORK-WIDE ISSUES

COASTAL CHANGES (INCLUDING CLIMATE AND SEA LEVEL RISE)

Sea surface temperature changes may impact food supply for marine birds at HALE, HAVO, NPSA, and possibly at KAHO, PUHO, and WAPA where seabird presence is not well documented. Compared to a multiple-year mean, the fledging success of Hawaiian petrels (*Pterodroma sandwichensis*) was lower in a year with a severe ENSO event, suggesting a possible impact to food resources for breeding petrels (C. Hodges, pers. comm.).

Severe weather events such as storms and floods during the breeding season can impact ground (nene, pueo, stilt) and open-cup nesting birds (forest birds). Parks with these resources include HALE, HAVO, KAHO, KALA, NPSA, ALKA, and possibly WAPA. Weather patterns and rainfall associated with ENSO events may also affect terrestrial fauna at WAPA. Other potential impacts of climate change on vertebrates are uncertain.

Sea level rise may result in the loss of wetlands and shoreline habitat for water birds at KAHO, ALKA, and AMME. Migratory shorebirds, which currently use shorelines in all network parks, may lose feeding and roosting habitat. In the Asan unit of WAPA, there are small seeps and springs near cliff bottoms that are associated with wetlands which are of concern. Shoreline-nesting seabirds, such as shearwaters at KAHO and possibly KALA, could lose nesting habitat due to sea level rise. Sea level rise could also cause turtles to lose habitat, especially nesting beaches for hawksbill turtles at HAVO and green sea turtles at NPSA, and can also cause a loss of basking beaches for green sea turtles at HAVO, KAHO, and PUHO. Monk seal pupping beaches may be lost at KALA if the shallow, protected pools used by young pups are submerged by rising sea water.

Water Withdrawal. PUHE wetland may be threatened by use of water by upslope developments. The drop in the water table due to upslope water withdrawal may also reduce freshwater inputs at KAHO, impacting endemic water birds and some shorebirds.

Other disturbances or catastrophes (tsunami, fire, extensive vegetative changes, urban encroachment). These large-scale, sudden changes have caused loss of habitat for Bulwer's petrels at HAVO (subsidence associated with a tsunami), and loss of forest for native birds from fire (HAVO, HALE, WAPA). Adjacent deforestation outside HAVO has further

reduced forest bird habitat. Loss or fragmentation of less disturbed buffer zones outside all parks has accelerated the invasion of alien plants and predators.

Increased human use could cause disturbance to shorebirds, basking and nesting turtles, and basking monk seals. Perhaps more significantly, shorelines outside parks are often heavily used or impacted by nearby development that brings large numbers of people, as well as pets and lights, into proximity of coastal wildlife. Thus, the protected confines of the national parks may become increasingly important refugia for these animals.

BIOLOGICAL INVASIONS

Predatory invasive species. Rats and feral cats are probably the two most serious predatory threats to native avifauna shared by all network parks. In addition, there are well-established populations of mongooses on most of the Hawaiian Islands and brown tree snakes on Guam. Water birds and ground nesting seabirds at KAHO are threatened by mongooses, rats, and feral cats. Hawaiian petrels, nene, and forest birds at HALE and HAVO are also impacted by these same predators. Rat impacts on elepaio have been documented at HAVO (Sarr et al. 1998). Rats and feral cats may prey on native forest birds and seabirds at NPSA, WAPA, and possibly AMME, and on shorebirds at all parks. Feral pigs, present in most Hawaii parks, as well as in NPSA and WAPA, prey on ground nesting birds, eggs, and chicks. Loose dogs pose occasional threats to wildlife at all parks. Ants threaten some native vertebrates; biting fire ants on islets of Oahu damaged the feet of wedge-tailed shearwater chicks. All parks with native birds and reptiles are at risk of the potential establishment of the brown tree snake; the nightingale reed warbler at AMME may be at highest risk due to its small population size and proximity of the park habitat to a harbor which could act as a conduit for snake introductions from nearby Guam. Besides rats, feral cats, and humans, there are currently no known established threats to birds or bats in NPSA. Hunting has been banned on the island and poaching does not seem to have an effect on the bats

Competition from invasive species. Competitive effects on native terrestrial animals are poorly documented. Scott et al. (1986) suggests that competition exists between Japanese white-eye and elepaio for insect food resources and between Japanese white-eye and iiwi for nectar food resources. The Polynesian-introduced mourning gecko is being displaced by a recently introduced lizard on Oahu, although the mechanism for this displacement is not known (E. Campbell, pers. comm.)

Facilitating spread of diseases or pathogens. Mosquitoes and alien birds are responsible for the establishment and spread of avian diseases, including malaria and pox, throughout Hawaii. Feral pigs create additional mosquito breeding sites by felling tree ferns and eating the trunks' interiors; thus, disease is more prevalent in forest areas with alien pigs (Atkinson, unpublished report). Avian disease may have caused or contributed to the extinction of several endemic Hawaiian birds, and currently threatens or limits many surviving species in HAVO, HALE, and possibly KALA. The presence of avian malaria (*Plasmodium spp.*) was documented in birds sampled from Tutuila, American Samoa (Jarvi et al. 2003). Due to a lack of extensive bird extinction records, further research is needed to determine malaria's overall effects on current bird populations in American Samoa. Stow-away vectors, imported alien birds, and other animals are potential sources of new diseases.

Impacts of aliens on important habitat components. Habitats for native species have been degraded by feral ungulates at HAVO, HALE, KALA, NPSA, WAPA, and ALKA. Rats probably impact native plant communities in all parks except USAR and has been documented at HAVO in recent broadcast toxicant work and at HALE in a food habit study (Cole et al. 1993). However, little information on the impacts of rats on native vertebrates has been described. Invasive alien plants appear to have displaced some native nene food plants.

ANTHROPOGENIC POLLUTION

AMME: Wetlands at AMME, which are habitat for the endangered nightingale reed warbler, are threatened by water quality degradation, flood control and run-off from town sewage, and encroaching development.

KAHO: KAHO includes numerous anchialine ponds, two fish ponds, and a large embayment. The park is located down slope of a growing industrial area and therefore leaching from upslope cesspools, septic tanks, and industrial development contributes to bacterial contamination and nutrient loading of water resources. A small boat harbor is located between park units and is a source of petroleum, heavy metals, and phosphates. The threat of sedimentation onto the coral reef is increased by pond restoration activities, erosion of the sandy shoreline, and dredging and/or expansion of the harbor. Rising sea level due to global warming may also contribute to erosion of the shoreline at KAHO.

KALA Feral pigs, deer, and cattle degrade stream resources in and around KALA. This adds to the stresses caused by stream diversion and run-off due to agriculture and urban development. Villages within the park may have problems with leaching of untreated sewage and PCBs.

NPSA: Ofu contains a closed dump site that continues to percolate water of unknown quality into the marine environment. Currently, pollution appears to be a minimal problem at NPSA (R. Monello, pers.comm.).

PUHE: A recreational harbor is adjacent to the park and beyond the harbor is a commercial shipping facility. These facilities contribute to the likelihood that marine recreation activities such as fishing and diving will increase, leading to a subsequent increase in fuel spills, pollution, and alteration of the substrate. Dirt biking along coral flats and stream beds, municipal and industrial wastewater discharges, residential and resort development, and land-based recreational activities all contribute to erosion and pollution of the near shore water. A stream originating upslope from the park is influenced by diversion, storm water run-off, and erosion of the top soil.

PUHO: Urban development up-slope from the park and the high level of tourism negatively impacts water quality of springs, fishponds, tide pools, and the near shore marine environment. Inland ponds are vulnerable to sedimentation and eutrophication. A submerged, natural discharge occurs, presumably through a lava tube, which is unique to this park and could be a conduit for contaminants originating upslope. Rising sea level due to global warming may eventually flood this low coastal park.

USAR: In Pearl Harbor, industrial and agricultural pollution are long-standing issues, and have contributed to the degradation of this estuary.

WAPA: The Asan unit contains wetlands which are susceptible to contamination from residential areas without sewers, as well as from flooding events which bring soil and agricultural runoff.

HABITAT RESTORATION

Habitat restoration includes forest, wetland, grassland, and potentially other habitat types within the network. This category also includes community “rehabilitation” which attempts to create somewhat novel habitats using native species adapted to an alien disturbance regime (e.g., fire) (Tunison and Loh 1995). Wetland habitat restoration to aid recovery of endangered Hawaiian water birds is in the planning stages at KAHO. Other habitat restoration work has been aimed primarily at native plant communities (various forest types, coastal strand, etc. at HAVO), and impacts on native terrestrial vertebrates have not been documented. The exception is native forest bird monitoring in recovering forest at HALE. Fences built to exclude feral ungulates also catch nesting seabirds and bats at HALE and HAVO. ALKA will encourage communities to engage in habitat restoration and can support existing community efforts aimed at habitat restoration along the trail. Strategically located restoration projects bordering NPS park units will benefit conservation efforts within parks. Furthermore, NPS units can teach community volunteers how to inventory, monitor, and restore native habitats. These skills could then be applied to trail and other areas adjacent to the park.

HUMAN HARVEST

In the past, both species of fruit bats at NPSA, the Pacific pigeon (*Ducula pacifica*), and the many-colored fruit dove (*Ptilinopus perousii*) were harvested for subsistence. Since the 1990s, there has been a ban on hunting these birds and bats. Although poaching of bats does occur, it does not seem to have an impact on the bat population. Over-fishing of near shore fish threatens the sustainability of resources and affects ecosystem balance along the ALKA trail corridor.

Table 1: Comparing Network-wide Issues Affecting Terrestrial Vertebrate Fauna by Park

| | Coastal Changes | Biological Invasions | Pollution | Habitat Restoration | Human Harvest |
|------|-----------------|----------------------|-----------|---------------------|---------------|
| ALKA | X | X | | X | X |
| AMME | X | X | X | | |
| HALE | X | X | | X | |
| HAVO | X | X | | X | |
| KAHO | X | X | X | X | |
| KALA | X | X | X | | |
| NPSA | X | X | X | | X |
| PUHE | X | X | X | | |
| PUHO | X | X | X | | |
| USAR | X | | X | | |
| WAPA | X | X | X | | |

Table 2. Critical Resources and Stressors identified by the Vertebrate Fauna Workgroup

| | Critical Resources | | | Stressors | | | |
|------|--------------------|--------------|----------------------------------|------------------------|-------------------|---------------------------------|------------------------------|
| | T & E Species | Rare Species | Species w/ Cultural Significance | Invasive Alien Species | Biodiversity Loss | Climate Change (sea level rise) | Fire or Altered fire regimes |
| ALKA | P | P | P | P | P | P | P |
| AMME | S | S | S | S | S | S | |
| HALE | S | S | S | S | S | S | S |
| HAVO | S | S | S | S | S | S | S |
| KAHO | S | S | S | S | S | S | S |
| KALA | S | S | S | S | S | S | P |
| NPSA | S | S | S | S | S | S | |
| PUHE | S | S | S | S | S | S | S |
| PUHO | S | S | S | S | S | S | S |
| USAR | | S | | | | | |
| WAPA | S | S | S | S | S | S | S |

P= Potential S= Self Identified

MONITORING

ALKA

There is currently no monitoring of vertebrate fauna at ALKA. However, because the trail passes through national parks, portions of it may have been included in various park inventory or monitoring programs.

ALKA Monitoring Needs: basic inventories of terrestrial vertebrate fauna

AMME

Currently birds are monitored by the Division of Fisheries & Wildlife, including the Christmas Bird Counts.

In cooperation with the CNMI CRM, the park has started a monitoring project for beach erosion.

The USGS Water Resources Division Hawaii District operates a network of water quality stations that collect information on streamflow, suspended sediment, lake and reservoir stage, groundwater level, salinity, rainfall, and evapotranspiration. The District also carries out interpretive studies on the quantity, quality, and dynamics of surface and groundwater (Hoffman 1995, USGS WRD 2003). Since 1994, DEQ has been monitoring water temperature, dissolved oxygen, pH, salinity, phosphate, total phosphorous, silicate, nitrate, nitrite, turbidity, and human health parameters. These have been monitored since 1994 on beaches for human health purposes.

The Herpetologist of the CNMI Division of Fish & Wildlife placed twenty snake traps in the wetland to capture Brown tree snake (*Boiga irregularis*). As of 1997 there have been no snakes caught in the traps in the CNMI. (Uyehara, 1997). However in the past ten years there have been approximately 40 documented reliable sighting with seven snakes found dead or alive (Vogt, 1997)

AMME Monitoring Needs: endangered birds, inland mangrove wetland hydrology, mangrove forest/ wetland assessment and restoration, basic inventories of terrestrial vertebrate fauna, freshwater aquatic invertebrates, terrestrial invertebrates

HALE

The park was included in the USFWS Hawaii Forest Bird Survey, which collected data on forest and upland birds, ungulate activity, vegetation, and incidental bird sightings.

The park participates in supra-annual forest bird counts conducted by the State and cooperators. This effort uses a subset of the former Hawaii Forest Bird Survey transects.

The Kipahulu Interdisciplinary Study (1983-4), included forest bird counts (P. Banko) and rat trapping on 500m transects (C. Stone). The subsequent Kipahulu Pig Research (1985-8) focused on ungulate activity.

In the Crater District, park staff monitors population trends, dynamics, threats, etc., of ground-nesting endangered birds (nene and uau). The effects of the removal of feral animals on uau populations are also monitored.

Forest bird populations are monitored in recovering rain-forest areas. This is the sole instance in the network of native vertebrate monitoring in response to habitat restoration.

The park monitors and removes introduced alien mammals.

HALE Monitoring Needs: threatened and endangered species, seabirds, forest birds and bats

HAVO

Two ongoing dominant vertebrate monitoring projects at HAVO are the nene monitoring project, which began in the early 1970s, and dark-rumped petrel monitoring on Mauna Loa, which began in the mid 1990s. The nene monitoring program provides population trend information in and adjacent to HAVO.

Nesting colonies of Hawaiian petrels are monitored for nest success and to assess if predator trapping efforts are effective.

Removal of feral ungulates (i.e., pigs and goats) was successfully completed during the 1970s through the 1990s. Monitoring for ingress of animals into fenced units within the park is carried out regularly to keep feral ungulate populations at zero.

Forest bird surveys in HAVO provided critical information on bird distribution and densities along moisture and elevational gradients. HAVO is uniquely situated along a moisture gradient (<1000 and > 4000 cm annual rainfall) ranging from wet to mesic to dry forests. Monitoring bird populations along this gradient provided insight into ecological dynamics and population responses. The park provided the only recent source of forest bird data along an elevational gradient (2000 to 7000 feet along the East Rift Zone to Mauna Loa Strip transects). However, this monitoring ceased in the mid 1990s. A long term monitoring program is essential to determine population fluctuations and changes, and species' range contractions/expansions.

HAVO Monitoring Needs: rare animal species, including endangered species and those that are examples of evolutionary processes; forest birds, procellarids and nene

KAHO

Wetland bird populations are monitored at Aimakapa pond through an agreement with Ducks Unlimited. Monitoring includes water bird populations, nesting, and fledgling success.

Semi-annual statewide water bird counts are conducted at KAHO, in cooperation with the State of Hawaii Division of Forestry and Wildlife.

Predator control monitoring is ongoing at KAHO to assess the effectiveness of control methods.

KAHO Monitoring Needs: endemic water birds, trends in populations of exotic animals.

KALA

Feral ungulate removal and monitoring occurs across the Puu Alii plateau (State Natural Area Reserve) adjacent to Kalaupapa, to prevent ingress of feral ungulates into the park.

Beaches at Kalaupapa are monitored for Hawaiian monk seal use.

Goats, pigs, and deer removal and monitoring are ongoing on the main peninsula of KALA, and has occurred on transects within Waikolu Valley.

KALA Monitoring Needs: abundance and distribution of all bird species throughout the park, forest bird trends, and procellarids. Medeiros et. al. (1996) recommended studies to determine the impacts of rodents on rare tree species at Kauhako crater.

NPSA

American Samoa Department of Marine and Wildlife Resources monitors bird and fruit bat populations territory-wide with some stations located within NPSA.

A seabird study, completed in 2003, assessed the size and extent of resident seabird populations (O'Connor and Rauzon 2003).

Feral pig control efforts are ongoing at NPSA. Snaring and activity data are collected along ten transects on Tutuila and three transects on Tau. The goal is to survey all transects at least once a year with areas of concern surveyed more frequently. Snares are present throughout the park.

NPSA Monitoring Needs: fruit bats, sheath tailed bats, rainforest birds, Tahitian petrel, and seabirds

PUHE

There is no known terrestrial vertebrate monitoring at PUHE.

PUHE Monitoring Needs: More extensive monitoring of bird populations needs to be extended over the year to gain a better understanding of potential use by rare species.

PUHO

No known terrestrial fauna monitoring has been done or is ongoing at this time at PUHO.

PUHO Monitoring Needs: threatened and endangered species, sensitive, native, and exotic animals

WAPA

In lands adjacent to WAPA, USGS and other organizations are working to prevent the brown tree snake from expanding its range and establishing in new areas. Visual and trapping methods, including dog use, are used to capture snakes to prevent their spread to other islands and to habitats designated for endangered or threatened species.

The USGS Brown Tree Snake Project on Guam has begun a project to evaluate small mammal trapping techniques for use in monitoring mammal densities on Guam and in CNMI. Work has been done in the Asan and Agat units of the park. USGS will decide whether to include a long term small mammal monitoring site within WAPA.

WAPA Monitoring Needs: species in limestone forests and tropical savannas, basic inventories of terrestrial vertebrate fauna

CONCLUSIONS

Native terrestrial vertebrates within PACN parks represent the remains of larger faunal assemblages that were lost both prehistorically and historically due to human influences. In most parks, the initial impact from humans was direct depredation, primarily for food. As is the case elsewhere, historic and current declines result primarily from the impacts of alien species and habitat loss. As a result of these declines, all network parks with known terrestrial vertebrates (excluding ALKA and USAR) may or do contain at least one federally endangered species. The proportion of native terrestrial fauna that is imperiled (federally threatened, endangered, or a candidate for listing) is startlingly high in some parks (e.g., 26% of HAVO's documented native fauna). Equally astounding is the number and proportion of alien terrestrial vertebrates. All network parks share roof rats and feral cats, probably the two most universal alien species on islands. One park, WAPA, has the brown tree snake, one of the most destructive alien vertebrates recorded; AMME probably has incipient populations of this species. The small wetland at AMME, if protected from the snake, may represent an opportunity to help prevent the nearly absolute loss of native land birds on Saipan that occurred on Guam. Similarly, the more pristine forests and coastal strand in NPSA represent opportunities for in situ conservation that were lost in the Hawaiian Islands. Early aggressive action to identify and contain invasive aliens will help conserve the largely intact ecosystems and their native vertebrate fauna. However, both

AMME and NPSA have a small staff base and limited funding. In the Hawaiian parks, restoration and rehabilitation of vegetation communities is underway and may expand habitat for some native birds and the bat. Partnerships with neighboring land owners are an effective tool used with increasing frequency in the Hawaii. Additionally, while some species will respond to habitat recovery and rehabilitation, other natives will need concentrated efforts to further elucidate and address causes of decline.

Native vertebrates in all PACN parks are at risk from alien threats not yet on the islands, including disease and the brown tree snake. Addressing the threat of these aliens will require action well outside park boundaries and sustained support of and/or collaboration with others. The PACN I&M program could play an important role in this effort by carefully documenting resources at risk and the impact of established invasive alien species.

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APPENDIX A: SUMMARY OF TERRESTRIAL VERTEBRATE FAUNA

Tables below are summaries of terrestrial fauna for each of the Pacific Island Network Parks, listed as “Present in Park” in the NPSpecies database.

ALKA: Little information exists regarding the terrestrial fauna at ALKA. Sections of the ALKA trail pass through other National Park boundaries and may include terrestrial fauna listed in those parks.

AMME: Migratory bird species can be seen along the coastal sections of the park. The small mangrove swamp within the park is an excellent habitat for native birds. Collared kingfishers, Micronesian honeyeaters, bridled and golden white-eyes, rufous fantails, and island swiftlets are often seen here. Two resident birds, the Marianas form of the common moorhen and the nightingale reed warbler, are endangered. The tidal flats between the "peninsula" and the east park boundary are among the best places on Saipan to see migrant shorebirds. Known mammals include feral cats and dogs (AMME staff, pers. comm.).

Table 3 Vertebrate fauna documented at AMME

| Standard Scientific Name | Standard Common Name |
|---------------------------------|----------------------------|
| <i>Suncus murinus</i> | house shrew |
| <i>Acrocephalus luscini</i> | nightingale reed-warbler |
| <i>Aerodramus vanikorensis</i> | gray swiftlet |
| <i>Aplonis opaca</i> | Micronesian starling |
| <i>Cleptornis marchei</i> | golden honeyeater |
| <i>Gallicolumba xanthonura</i> | white-throated ground-dove |
| <i>Gygis alba</i> | white tern |
| <i>Halcyon chloris</i> | white-collared kingfisher |
| <i>Ixobrychus sinensis</i> | Chinese bittern |
| <i>Myzomela rubratra</i> | Micronesian honeycreeper |
| <i>Perochirus ateles</i> | Fragile Micronesian gecko |
| <i>Ptilinopus roseicapilla</i> | Marianas fruit-dove |
| <i>Rhipidura rufifrons</i> | rufous-fronted fantail |
| <i>Zosterops conspicillatus</i> | bridled white-eye |

HALE: The west crater rim, especially near the summit, provides most of the remaining and best protected habitat for the endangered Hawaiian petrel (*Pterodroma phaeopygia sandwichensis*). The crater is also one of the major sites in the Hawaiian Islands where the endangered Hawaiian goose (*Branta sandvicensis*) has been reintroduced from captive-bred populations. Both species are depredated by mongooses, feral cats, feral dogs, and rats. Park predator control programs have helped improve the status of these two species. In general, introduced herbivores, primarily feral goats (*Capra hircus*), cattle (*Bos taurus*), and sheep (*Ovis aries*), were recognized as the primary obstacle to preservation of the native biota. Other threats to the resources include feral goats, feral pigs, Axis deer, mongooses, three species of rats, feral cats, alien bird species, and numerous alien invertebrate species including predatory yellow-jacket wasps and several species of ants. Fencing of the crater district has helped reduced the

natural resources destruction by feral ungulates. Seven of HALE's native birds are federally threatened or endangered.

Table 4 Vertebrate fauna documented at HALE

| Standard Scientific Name | Standard Common Name |
|--------------------------------------|-----------------------------|
| <i>Axis axis</i> | axis deer |
| <i>Bos taurus</i> | domestic cattle |
| <i>Canis familiaris</i> | domestic dog |
| <i>Capra hircus</i> | goat |
| <i>Felis silvestris</i> | domestic cat |
| <i>Herpestes auropunctatus</i> | mongoose |
| <i>Lasiurus cinereus semotus</i> | Hawaiian hoary bat |
| <i>Mus musculus</i> | house mouse |
| <i>Rattus exulans</i> | Polynesian rat |
| <i>Rattus norvegicus</i> | Norway rat |
| <i>Rattus rattus</i> | black rat |
| <i>Sus scrofa</i> | pig |
| <i>Acridotheres tristis</i> | common myna |
| <i>Alauda arvensis arvensis</i> | sky lark |
| <i>Alectoris chukar</i> | chukar |
| <i>Anas wyvilliana</i> | Hawaiian duck, koloa |
| <i>Anous minutus melanogenys</i> | Hawaiian noddy, black noddy |
| <i>Asio flammeus sandwichensis</i> | Hawaiian short-eared owl |
| <i>Branta sandvicensis</i> | Hawaiian Goose, Nene |
| <i>Bubulcus ibis</i> | cattle egret |
| <i>Callipepla californica</i> | California quail |
| <i>Cardinalis cardinalis</i> | northern cardinal |
| <i>Carpodacus mexicanus</i> | house finch |
| <i>Cettia diphone</i> | Japanese bush-warbler |
| <i>Columba livia</i> | rock dove |
| <i>Francolinus pondicerianus</i> | gray francolin |
| <i>Fregata minor palmerstoni</i> | great frigatebird |
| <i>Garrulax canorus</i> | melodious laughing thrush |
| <i>Geopelia striata</i> | zebra dove |
| <i>Hemignathus lucidus affinis</i> | Maui nukupuu |
| <i>Hemignathus virens wilsoni</i> | Maui amakihi |
| <i>Heteroscelus incanus</i> | wandering tattler |
| <i>Himatione sanguinea sanguinea</i> | apapane |
| <i>Leiothrix lutea</i> | red-billed leiothrix |

| | |
|--------------------------------------|--|
| <i>Lonchura malabarica</i> | warbling silverbill |
| <i>Lonchura punctulata</i> | nutmeg mannikin |
| <i>Loxops coccineus ochraceus</i> | akepa (Maui) |
| <i>Mimus polyglottos</i> | northern mockingbird |
| <i>Nycticorax nycticorax hoactli</i> | black-crowned night heron |
| <i>Oceanodroma castro</i> | band-rumped storm-petrel |
| <i>Palmeria dolei</i> | akohekohe, crested honeycreeper |
| <i>Paroreomyza montana</i> | Maui creeper |
| <i>Paroreomyza montana newtoni</i> | Lanai creeper, Maui creeper |
| <i>Passer domesticus</i> | house sparrow |
| <i>Phaethon lepturus dorotheae</i> | white-tailed tropicbird |
| <i>Phasianus colchicus</i> | ring-necked pheasant |
| <i>Pluvialis fulva</i> | Pacific golden plover |
| <i>Pseudonestor xanthophrys</i> | Maui honeycreeper, Maui parrotbill |
| <i>Pterodroma sandwichensis</i> | Hawaiian petrel |
| <i>Puffinus auricularis</i> | ao, manx, newell's townsend's shearwater |
| <i>Streptopelia chinensis</i> | spotted dove |
| <i>Tyto alba</i> | common barn-owl |
| <i>Vestiaria coccinea</i> | iiwi |
| <i>Zosterops japonicus</i> | Japanese white-eye |
| <i>Lampropholis delicata</i> | garden skink, metallic skink |
| <i>Lepidodactylus lugubris</i> | mourning gecko |
| <i>Ramphotyphlops braminus</i> | Brahminy blind snake |
| <i>Bufo marinus</i> | giant toad, marine toad |
| <i>Rana catesbeiana</i> | Bullfrog |

HAVO: Five of the park's resident terrestrial vertebrate species are endangered or threatened: nene, Hawaiian petrels, hawksbill sea turtle, Hawaiian hoary bat, and Hawaiian hawk. The threatened Newell's Shearwater may occur in the park. Non-native vertebrates consist of feral goats, feral pigs, mouflon sheep, mongooses, three species of rats, feral cats, and 22 alien bird species. An additional four native forest birds have been lost in the past thirty years (extirpation of Hawaii Akepa, Hawaii Creeper and Akiapolaau, and extinction of Ou).

Table 5 Vertebrate fauna documented at HAVO

| Standard Scientific Name | Standard Common Name |
|----------------------------------|----------------------|
| <i>Canis familiaris</i> | domestic dog |
| <i>Felis silvestris</i> | domestic cat |
| <i>Herpestes auropunctatus</i> | Indian mongoose |
| <i>Lasiurus cinereus semotus</i> | Hawaiian hoary bat |
| <i>Mus musculus</i> | house mouse |

| | |
|---|-----------------------------|
| <i>Ovis aries musimon</i> | Mouflon sheep |
| <i>Rattus exulans</i> | Polynesian rat |
| <i>Rattus norvegicus</i> | Norway rat |
| <i>Rattus rattus</i> | black rat |
| <i>Sus scrofa</i> | pig |
| <i>Acridotheres tristis</i> | common myna |
| <i>Alauda arvensis arvensis</i> | sky lark |
| <i>Alectoris chukar</i> | chukar |
| <i>Anous minutus melanogenys</i> | Hawaiian noddy, black noddy |
| <i>Arenaria interpres</i> | ruddy turnstone |
| <i>Asio flammeus sandwichensis</i> | Hawaiian short-eared owl |
| <i>Branta sandvicensis</i> | Hawaiian goose, nene |
| <i>Bubulcus ibis</i> | cattle egret |
| <i>Buteo solitarius</i> | Hawaiian hawk, lo |
| <i>Calidris alba</i> | sanderling |
| <i>Callipepla californica</i> | California quail |
| <i>Cardinalis cardinalis</i> | northern cardinal |
| <i>Carpodacus mexicanus</i> | house finch |
| <i>Chasiempis sandwichensis sandwichensis</i> | Hawaii elepaio |
| <i>Coturnix japonica</i> | Japanese quail |
| <i>Francolinus adspersus</i> | red-billed francolin |
| <i>Francolinus erckelii</i> | Erckel's francolin |
| <i>Fregata minor palmerstoni</i> | great frigatebird |
| <i>Garrulax canorus</i> | melodious laughing thrush |
| <i>Geopelia striata</i> | zebra dove |
| <i>Hemignathus virens virens</i> | Hawaii amakihi |
| <i>Heteroscelus incanus</i> | wandering tattler |
| <i>Himatione sanguinea sanguinea</i> | apapane |
| <i>Leiothrix lutea</i> | red-billed leiothrix |
| <i>Lonchura punctulata</i> | nutmeg mannikin |
| <i>Lophura leucomelanos</i> | Kalij pheasant |
| <i>Meleagris gallopavo</i> | wild turkey |
| <i>Myadestes obscurus</i> | omao |
| <i>Numenius tahitiensis</i> | bristle-thighed curlew |
| <i>Oceanodroma castro</i> | band-rumped storm-petrel |
| <i>Passer domesticus</i> | house sparrow |
| <i>Phaethon lepturus dorotheae</i> | white-tailed tropicbird |
| <i>Phalaropus fulicaria</i> | red phalarope |

| | |
|--|---|
| <i>Phasianus colchicus</i> | ring-necked pheasant |
| <i>Pluvialis fulva</i> | Pacific golden plover |
| <i>Pterodroma sandwichensis</i> | Hawaiian petrel |
| <i>Sicalis flaveola</i> | saffron finch |
| <i>Streptopelia chinensis</i> | spotted dove |
| <i>Tyto alba</i> | common barn-owl |
| <i>Vestiaria coccinea</i> | iiwi |
| <i>Zosterops japonicus</i> | Japanese white-eye |
| <i>Cryptoblepharus poecilopleurus</i> | Oceanic snake-eyed skink |
| <i>Hemidactylus frenatus</i> | bridled house gecko, common house gecko |
| <i>Lampropholis delicata</i> | garden skink, metallic skink |
| <i>Trachemys scripta elegans</i> | red-eared slider |
| <i>Bufo marinus</i> <i>Rana catesbeiana</i> | giant toad, marine toad bullfrog |

KAHO: The park contains some of few wetlands habitats suitable for native birds on the Island of Hawaii. Aimakapa and Kaloko ponds are especially important areas for protecting rare and endangered bird species such as the Hawaiian coot and Hawaiian stilt. A wide variety of accidental or rare stragglers have been recorded at the ponds and park coastline. Several species of migratory waterfowl often winter at the ponds. Water birds are threatened by periodic outbreaks of avian botulism as well as by feral cat, rat, and mongoose predation. Occasional sightings of the endangered Hawaiian bat have been made in the park.

Table 6 Vertebrate fauna documented at KAHO

| Standard Scientific Name | Standard Common Name |
|----------------------------------|----------------------|
| <i>Canis familiaris</i> | domestic dog |
| <i>Felis silvestris</i> | domestic cat |
| <i>Herpestes auropunctatus</i> | Indian mongoose |
| <i>Lasiurus cinereus semotus</i> | Hawaiian hoary bat |
| <i>Mus musculus</i> | house mouse |
| <i>Rattus exulans</i> | Polynesian rat |
| <i>Rattus norvegicus</i> | Norway rat |
| <i>Rattus rattus</i> | black rat |
| <i>Acridotheres tristis</i> | common myna |
| <i>Actitis macularia</i> | spotted sandpiper |
| <i>Anas acuta</i> | northern pintail |
| <i>Anas americana</i> | American wigeon |
| <i>Anas clypeata</i> | northern shoveler |
| <i>Anas crecca</i> | green-winged teal |
| <i>Anas cyanoptera</i> | cinnamon teal |
| <i>Anas discors</i> | blue-winged teal |

| | |
|--------------------------------------|-----------------------------|
| <i>Anas penelope</i> | Eurasian wigeon |
| <i>Anas platyrhynchos</i> | mallard |
| <i>Anas querquedula</i> | garganey |
| <i>Anas strepera</i> | gadwall |
| <i>Anous minutus melanogenys</i> | Hawaiian noddy, black noddy |
| <i>Arenaria interpres</i> | ruddy turnstone |
| <i>Asio flammeus sandwichensis</i> | Hawaiian short-eared owl |
| <i>Aythya affinis</i> | lesser scaup |
| <i>Aythya americana</i> | redhead |
| <i>Aythya collaris</i> | ring-necked duck |
| <i>Aythya marila</i> | greater scaup |
| <i>Aythya valisineria</i> | canvasback |
| <i>Branta bernicla</i> | brant |
| <i>Bubulcus ibis</i> | cattle egret |
| <i>Calidris acuminata</i> | sharp-tailed sandpiper |
| <i>Calidris alba</i> | sanderling |
| <i>Calidris alpina</i> | dunlin |
| <i>Calidris mauri</i> | western sandpiper |
| <i>Calidris melanotos</i> | pectoral sandpiper |
| <i>Calidris minutilla</i> | least sandpiper |
| <i>Calidris ruficollis</i> | red-necked stint |
| <i>Cardinalis cardinalis</i> | northern cardinal |
| <i>Carpodacus mexicanus</i> | house finch |
| <i>Ceryle alcyon</i> | belted kingfisher |
| <i>Charadrius semipalmatus</i> | semipalmated plover |
| <i>Chlidonias niger</i> | black tern |
| <i>Egretta thula</i> | snowy egret |
| <i>Estrilda caerulescens</i> | lavender waxbill |
| <i>Fringilla monticola</i> | black chinch |
| <i>Fringilla monticola</i> | black chinch |
| <i>Fringilla monticola</i> | black chinch |
| <i>Fregata minor palmerstoni</i> | great frigatebird |
| <i>Fulica alai</i> | Hawaiian Coot |
| <i>Fulica americana americana</i> | American Coot |
| <i>Geopelia striata</i> | zebra dove |
| <i>Heteroscelus incanus</i> | wandering tattler |
| <i>Himantopus mexicanus knudseni</i> | Hawaiian stilt, aeo |
| <i>Larus atricilla</i> | laughing gull |
| <i>Larus delawarensis</i> | ring-billed gull |
| <i>Larus glaucescens</i> | glaucous-winged gull |

| | |
|--|---------------------------|
| <i>Larus philadelphia</i> | Bonaparte's gull |
| <i>Larus pipixcan</i> | Franklin's gull |
| <i>Limnodromus</i> | dowitchers |
| <i>Limnodromus griseus</i> | short-billed dowitcher |
| <i>Limnodromus scolopaceus</i> | long-billed dowitcher |
| <i>Limosa lapponica</i> | bar-tailed godwit |
| <i>Lonchura malabarica</i> | warbling silverbill |
| <i>Lonchura punctulata</i> | nutmeg mannikin |
| <i>Lophodytes cucullatus</i> | hooded merganser |
| <i>Mimus polyglottos</i> | northern mockingbird |
| <i>Numenius tahitiensis</i> | bristle-thighed curlew |
| <i>Nycticorax nycticorax hoactli</i> | black-crowned night heron |
| <i>Padda oryzivora</i> | java sparrow |
| <i>Pandion haliaetus</i> | osprey |
| <i>Paroaria capitata</i> | yellow-billed cardinal |
| <i>Passer domesticus</i> | house sparrow |
| <i>Phalaropus tricolor</i> | Wilson's phalarope |
| <i>Plegadis chihi</i> | white-faced ibis |
| <i>Pluvialis fulva</i> | Pacific golden plover |
| <i>Pluvialis squatarola</i> | black-bellied plover |
| <i>Podilymbus podiceps</i> | pie-billed grebe |
| <i>Puffinus pacificus chlororhynchus</i> | wedge-tailed shearwater |
| <i>Serinus mozambicus</i> | yellow-fronted canary |
| <i>Sicalis flaveola</i> | saffron finch |
| <i>Sterna albifrons</i> | little tern |
| <i>Sterna antillarum</i> | least tern |
| <i>Streptopelia chinensis</i> | spotted dove |
| <i>Sula leucogaster plotus</i> | a, brown booby |
| <i>Tringa flavipes</i> | lesser yellowlegs |
| <i>Tyto alba</i> | common barn-owl |
| <i>Zosterops japonicus</i> | Japanese white-eye |

KALA: The park provides habitat for the Hawaiian petrel (Uau), Newell's shearwater (Ao), and the endangered Hawaiian monk seal. Introduced animals include axis deer, feral goats, feral pigs, mongoose, and rats. The vegetation of KALA is threatened by feral goats, pigs, and axis deer. Ungulates are the most damaging to the park's resources, especially in the dry forest. Pigs are a particular problem on the Puu Alii plateau and in Waikolu Valley. Detrimental effects include direct destruction through digging and herbivory. Erosion, caused by loose soil and reduced vegetation, reduces soil quality and affects stream resources, increasing sedimentation and affecting nutrient load. Other invasive animals are also important threats: rats eat native snails,

plant seeds, and bird eggs; mongooses eat bird eggs, chicks, and adults. Avian disease has probably played a large role in the loss of native Hawaiian forest birds at Kalaupapa and on Molokai in general. There have been recent sightings of iiwi at The Nature Conservancy's Kamakou preserve (S. Aruch pers. comm.). Off-shore islets provide nesting habitat for seabirds.

Table 7 Vertebrate fauna documented at KALA

| Standard Scientific Name | Standard Common Name |
|--|--|
| <i>Axis axis</i> | axis deer |
| <i>Canis familiaris</i> | domestic dog |
| <i>Capra hircus</i> | goat |
| <i>Equus caballus</i> | horse |
| <i>Felis silvestris</i> | domestic cat |
| <i>Herpestes auropunctatus</i> | Indian mongoose |
| <i>Mus musculus</i> | house mouse |
| <i>Rattus exulans</i> | Polynesian rat |
| <i>Rattus norvegicus</i> | Norway rat |
| <i>Rattus rattus</i> | black rat |
| <i>Sus scrofa</i> | pig |
| <i>Anous minutus melanogenys</i> | Hawaiian noddy, black noddy |
| <i>Bulweria bulwerii</i> | Bulwer's petrel |
| <i>Carpodacus mexicanus</i> | house finch |
| <i>Cettia diphone</i> | Japanese bush-warbler |
| <i>Francolinus francolinus</i> | black francolin |
| <i>Fregata minor palmerstoni</i> | great frigatebird |
| <i>Hemignathus virens wilsoni</i> | Maui amakihi |
| <i>Himatione sanguinea sanguinea</i> | apapane |
| <i>Leiothrix lutea</i> | red-billed leiothrix |
| <i>Phaethon lepturus dorotheae</i> | white-tailed tropicbird |
| <i>Phaethon rubricauda rothschildi</i> | red-tailed tropicbird |
| <i>Puffinus auricularis</i> | ao, manx, newell's townsend's shearwater |
| <i>Puffinus pacificus chlororhynchus</i> | Wedge-tailed shearwater |
| <i>Streptopelia chinensis</i> | spotted dove |
| <i>Sula leucogaster plotus</i> | a, brown booby |
| <i>Sula sula rubripes</i> | red-footed booby |
| <i>Vestiaria coccinea</i> | iiwi |
| <i>Zosterops japonicus</i> | Japanese white-eye |
| <i>Cryptoblepharus poecilopleurus</i> | Oceanic snake-eyed skink |
| <i>Gehyra mutilata</i> | stump-toed gecko |
| <i>Hemidactylus frenatus</i> | bridled house gecko, common house gecko |
| <i>Hemidactylus garnotii</i> | Indo-Pacific gecko, fox gecko |

| | |
|---------------------------------|---|
| <i>Hemiphyllodactylus typus</i> | Indo-Pacific tree gecko, small tree gecko |
| <i>Lampropholis delicata</i> | garden skink, metallic skink |
| <i>Lepidodactylus lugubris</i> | mourning gecko |
| <i>Lipinia noctua</i> | moth skink |
| <i>Bufo marinus</i> | giant toad, marine toad |

NPSA: National Park of American Samoa has three native bat species, 25 resident land and water birds, 20 resident seabirds, 7 skinks, 4 geckos, 2 sea turtles, 1 snake, and occasional other visitors. Introduced non-native vertebrates include rats (Polynesian, roof, Norway), house mouse, dogs, feral pigs, cats, marine toads, house gecko, and birds (jungle and common myna, bulbuls).

Table 8 Vertebrate fauna documented at NPSA

| Standard Scientific Name | Standard Common Name |
|---------------------------------|-----------------------------|
| <i>Emballonura semicaudata</i> | Mariana sheath-tailed bat |
| <i>Pteropus samoensis</i> | Samoa flying fox |
| <i>Pteropus tonganus</i> | insular flying fox |
| <i>Sus scrofa</i> | pig, pig (feral) |
| <i>Collocalia spodiopygia</i> | white-rumped swiftlet |
| <i>Anous minutus</i> | black noddy |
| <i>Anous stolidus</i> | brown noddy |
| <i>Aplonis atrifusca</i> | Samoa starling |
| <i>Aplonis tabuensis</i> | Polynesian starling |
| <i>Clytorhynchus vitiensis</i> | Fiji shrikebill |
| <i>Ducula pacifica</i> | Pacific pigeon |
| <i>Eudynamis taitensis</i> | long-tailed cuckoo |
| <i>Foulehaio carunculata</i> | wattled honeyeater |
| <i>Fregata ariel</i> | lesser frigatebird |
| <i>Fregata minor</i> | great frigatebird |
| <i>Gygis alba</i> | white tern |
| <i>Todiramphus chloris</i> | white-collared kingfisher |
| <i>Myzomela cardinalis</i> | cardinal honeyeater |
| <i>Nesofregatta albigularis</i> | white throated storm petrel |
| <i>Phaethon lepturus</i> | white-tailed tropicbird |
| <i>Porphyrio porphyrio</i> | purple swamphen |
| <i>Procelsterna cerulea</i> | blue-gray noddy |
| <i>Pterodroma leucoptera</i> | collared petrel |
| <i>Pterodroma rostrata</i> | Tahiti petrel |
| <i>Ptilinopus perousii</i> | many-colored fruit-dove |
| <i>Ptilinopus porphyraceus</i> | purple-capped fruit-dove |

| | |
|---------------------------------|--|
| <i>Puffinus lherminieri</i> | Audubon's shearwater |
| <i>Puffinus nativitatis</i> | Christmas shearwater |
| <i>Puffinus pacificus</i> | wedge-tailed shearwater |
| <i>Gallirallus philippensis</i> | banded rail |
| <i>Sula leucogaster</i> | brown booby |
| <i>Sula sula</i> | red-footed booby |
| <i>Vini australis</i> | blue-crowned lory |
| <i>Candoia bibroni</i> | Bibron's keel-scaled boa, Pacific tree boa |
| <i>Lipinia noctua</i> | moth skink |
| <i>Gehyra oceanica</i> | Polynesian gecko |
| <i>Emoia cyanura</i> | Azure-tailed skink |
| <i>Emoia lawesii</i> | Lawes' emoia, Lawes' skink |
| <i>Emoia nigra</i> | black emoia, black skink |
| <i>Emoia samoensis</i> | Samoan emoia, Samoan skink |

PUHE : Terrestrial vertebrate fauna at PUHE consists almost entirely of introduced species such as mongooses, rats, and mice. Alien bird species include the Japanese white-eye, house sparrow, common myna, rock dove, and the northern cardinal. Native bird species may include visits but no nesting of aukuu (*Nycticorax nycticorax hoactli*) and pueo (*Asio flammeus sandwichensis*).

Table 9 Vertebrate fauna documented at PUHE

| Standard Scientific Name | Standard Common Name |
|------------------------------------|--------------------------|
| <i>Herpestes auropunctatus</i> | Indian mongoose |
| <i>Mus musculus</i> | house mouse |
| <i>Rattus exulans</i> | Polynesian rat |
| <i>Rattus norvegicus</i> | Norway rat |
| <i>Rattus rattus</i> | black rat |
| <i>Acridotheres tristis</i> | common myna |
| <i>Alauda arvensis arvensis</i> | sky lark |
| <i>Arenaria interpres</i> | ruddy turnstone |
| <i>Asio flammeus sandwichensis</i> | Hawaiian short-eared owl |
| <i>Branta</i> | brent geese |
| <i>Branta bernicla</i> | brant |
| <i>Branta canadensis minima</i> | cackling goose |
| <i>Calidris alba</i> | sanderling |
| <i>Cardinalis cardinalis</i> | northern cardinal |
| <i>Carpodacus mexicanus</i> | house finch |
| <i>Charadrius semipalmatus</i> | semipalmated plover |
| <i>Columba livia</i> | rock dove |

| | |
|--------------------------------------|---------------------------|
| <i>Francolinus francolinus</i> | black francolin |
| <i>Francolinus pondicerianus</i> | gray francolin |
| <i>Fregata minor palmerstoni</i> | great frigatebird |
| <i>Fulica</i> | coots |
| <i>Geopelia striata</i> | zebra dove |
| <i>Heteroscelus incanus</i> | wandering tattler |
| <i>Larus delawarensis</i> | ring-billed gull |
| <i>Larus philadelphia</i> | Bonaparte's gull |
| <i>Larus pipixcan</i> | Franklin's gull |
| <i>Limnodromus griseus</i> | short-billed dowitcher |
| <i>Lonchura malabarica</i> | warbling silverbill |
| <i>Lonchura punctulata</i> | nutmeg mannikin |
| <i>Mimus polyglottos</i> | northern mockingbird |
| <i>Nycticorax nycticorax hoactli</i> | black-crowned night heron |
| <i>Paroaria capitata</i> | yellow-billed cardinal |
| <i>Passer domesticus</i> | house sparrow |
| <i>Pluvialis fulva</i> | Pacific golden plover |
| <i>Serinus mozambicus</i> | yellow-fronted canary |
| <i>Sicalis flaveola</i> | saffron finch |
| <i>Sterna albifrons</i> | little tern |
| <i>Sterna antillarum</i> | least tern |
| <i>Sterna caspia</i> | Caspian tern |
| <i>Streptopelia chinensis</i> | spotted dove |
| <i>Sula leucogaster plotus</i> | a, brown booby |
| <i>Zenaida macroura</i> | mourning dove |
| <i>Zosterops japonicus</i> | Japanese white-eye |

PUHO: Birds are the predominant form of terrestrial vertebrate fauna found within the park. The 1996 Cooperative National Park Resource Studies Unit report on the birds of the park was based on counts made in September and October 1992 and March 1993. A total of 12 bird species were detected during these counts. During both of those periods, no indigenous birds, other than migratory shorebirds, were seen. The Japanese white-eye (*Zosterops japonica*) and the common myna (*Acridotheres tristis*) were the most widespread and common species seen in the park. The Hawaiian hoary bat (*Lasiurus cinereus semotus*), the only mammal native to the Hawaiian Islands, commonly forages for flying insect prey over open areas such as forest clearings, lava fields, and nearshore coastal waters such as those found adjacent to the park. Sightings have been occasional and only at night over the offshore waters of the park. The Hawaiian bat is listed as an endangered species. No other threatened or endangered animal species are found within the national park. Introduced mammals include mongoose, cats, rats, and mice. The presence of mongooses and feral cats reduces the opportunity for native birds to become reestablished in the wetland. Reptiles commonly found in the park include three species

of geckos and three species of skinks. Geckos are more active at night, usually seen in houses or on screens catching insects attracted to lights. Skinks are more active during the day, commonly seen sunning themselves or darting in search of insects in the open or from under rocks.

Table 10 Vertebrate fauna documented at PUHO

| Standard Scientific Name | Standard Common Name |
|--------------------------------------|-----------------------------|
| <i>Canis familiaris</i> | domestic dog |
| <i>Felis silvestris</i> | domestic cat |
| <i>Herpestes auropunctatus</i> | Indian mongoose |
| <i>Lasiurus cinereus semotus</i> | Hawaiian hoary bat |
| <i>Mus musculus</i> | house mouse |
| <i>Rattus exulans</i> | Polynesian rat |
| <i>Rattus norvegicus</i> | Norway rat |
| <i>Rattus rattus</i> | black rat |
| <i>Sus scrofa</i> | pig |
| <i>Acridotheres tristis</i> | common myna |
| <i>Arenaria interpres</i> | ruddy turnstone |
| <i>Asio flammeus sandwichensis</i> | Hawaiian short-eared owl |
| <i>Buteo solitarius</i> | Hawaiian hawk, lo |
| <i>Cardinalis cardinalis</i> | northern cardinal |
| <i>Carpodacus mexicanus</i> | house finch |
| <i>Estrilda caerulescens</i> | lavender waxbill |
| <i>Francolinus erckelii</i> | Erckel's francolin |
| <i>Geopelia striata</i> | zebra dove |
| <i>Heteroscelus incanus</i> | wandering tattler |
| <i>Himantopus mexicanus knudseni</i> | Hawaiian stilt, aeo |
| <i>Lonchura malabarica</i> | warbling silverbill |
| <i>Lonchura punctulata</i> | nutmeg mannikin |
| <i>Numenius tahitiensis</i> | bristle-thighed curlew |
| <i>Nycticorax nycticorax hoactli</i> | Black-crown night heron |
| <i>Paroaria capitata</i> | yellow-billed cardinal |
| <i>Passer domesticus</i> | house sparrow |
| <i>Phasianus colchicus</i> | ring-necked pheasant |
| <i>Pluvialis fulva</i> | Pacific golden plover |
| <i>Serinus mozambicus</i> | yellow-fronted canary |
| <i>Sicalis flaveola</i> | saffron finch |
| <i>Streptopelia chinensis</i> | spotted dove |
| <i>Sula leucogaster plotus</i> | a, brown booby |
| <i>Tyto alba</i> | common barn-owl |
| <i>Zosterops japonicus</i> | Japanese white-eye |

USAR: No terrestrial vertebrate fauna species list was found for USAR.

WAPA: Of War in the Pacific National Historical Park's native forest birds, only one species, the swiftlet, may still remain. The rest (12 species) are gone. No other national park has suffered such a massive loss of its biodiversity. The brown tree snake numbers, at the height of its invasion, were immense. In prime habitats, snake numbers were estimated to be 12,000 snakes per square mile, perhaps the greatest density of snakes anywhere in the world. With a massive decline in prey, snake numbers are much less. Still, resilient populations of alien mice, rats, lizards, and geckos support a sizable snake population, particularly in villages.

Table 11 Vertebrate fauna documented at WAPA

| Standard Scientific Name | Standard Common Name |
|---------------------------------|-----------------------------|
| <i>Canis familiaris</i> | domestic dog |
| <i>Cervus mariannus</i> | Philippine deer |
| <i>Felis silvestris</i> | domestic cat |
| <i>Rattus spp.</i> | rat |
| <i>Sus scrofa</i> | pig |
| <i>Ardea herodias</i> | great blue heron |
| <i>Anolis carolinensis</i> | green anole |
| <i>Hemidactylus frenatus</i> | common house gecko |
| <i>Varanus</i> | monitor lizards |
| <i>Gehyra mutilata</i> | stump-toed gecko |
| <i>Carlia fusca</i> | brown four-fingered skink |
| <i>Boiga irregularis</i> | brown tree snake |
| <i>Bufo marinus</i> | marine toad |
| <i>Birgus latro</i> | coconut crab |